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Metal sorption on clay minerals aiming at the geological storage of nuclear wastes

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The design of a nuclear waste repository is a challenging technological enterprise. The reasons are intrinsically related to the nature of the problem: the storage of a variety oC. f radioactive materials for a period longer than human history. The potential consequences of a repository failure are dramatic because they lead to high environmental impact and economical costs of remediation [1]. Repository implementation should therefore rely on deep process understanding and intrinsic passive safety of geological systems. Modern approaches to the geological storage of nuclear wastes deal with a careful site selection and a multi-barrier system. The Swiss waste disposal program is currently in the final stage of the site selection process. Three geological location identified as potential disposal sites are located in Opalinus Clay formations. The multi-barrier disposal concept is heavily relying on the physical and chemical properties of clay minerals, in particular, their interaction with radionuclides [2].

The minerals clays of interest (illite and montmorillonite) were studied over years to derive empirically the sorption properties necessary for the safety assessments. Natural systems are heterogeneous in terms of mineralogical and chemical composition. The experimental studies are limited to a finite number of scenarios, simplified chemistry and short timescale. A mechanistic description of the sorption processes is necessary to transfer the data obtained from simplified reference systems to complex natural environments using computational models based on physical and chemical process understanding. A synthetic clay, saponite, was selected as the customizable and chemically pure starting material. Sorption experiments were carried out to obtain sorption isotherms for a divalent transition metal (nickel) and a trivalent lanthanide (lutetium). The mechanistic information about the sorption processes was achieved by X-ray spectroscopy techniques that have been carried out at the Rosseldorf Beamline at the European Synchrotron Radiation Facility. The spectroscopic data are interpreted with help of ab initio molecular dynamics simulations.

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